contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer or smart phone, or user equipment.

[0077] As used in this application, the term "circuitry" refers to all of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and (b) to combinations of circuits and software (and/or firmware), such as (as applicable): (i) to a combination of processor(s) or (ii) to portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and (c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present. This definition of 'circuitry' applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" would also cover, for example and if applicable to the particular claim element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in server, a cellular network device, or other network device.

[0078] If desired, the different functions discussed herein may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the above-described functions may be optional or may be combined.

[0079] Although various aspects of the invention are set out in the independent claims, other aspects of the invention comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

[0080] It should also be understood that the above described example embodiments of the invention are not to be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present invention as defined in the appended claims.

[0081] The following meanings for the abbreviations used in this specification apply:

[0082] 3GPP The 3rd Generation Partnership Project

[0083] ACK Positive Acknowledgment

[0084] CA Carrier Aggregation

[0085] DCI Downlink Control Information

[0086] DL Downlink

[0087] DRX Discontinuous Reception

[0088] eICIC Enhanced Inter-cell Interference Coordination

[0089] F1bwcs Format 1b with Channel Selection

[0090] F3 Format 3

[0091] FD Frequency Domain

[0092] L1 Layer 1

[0093] L2 Layer 2

[0094] L3 Layer 3

[0095] LTE Long Term Evolution

[0096] LTE-A Long Term Evolution Advanced

[0097] MBSFN Multicast-broadcast Single-frequency Network

[0098] NACK Negative Acknowledgment

[0099] PCell Primary Cell

[0100] PDCCH Physical Downlink Control Channel

[0101] PUCCH Physical Uplink Control Channel

[0102] PRB Physical Resource Block

[0103] Rel Release

[0104] RRC Radio Resource Control

[0105] SCell Secondary Cell

[0106] TD Time Domain

[0107] TPC Transmit Power Control

[0108] TRF Time Reuse Factor

[0109] TRP Time Reuse Pattern

[0110] TTI Transmission Time Interval

[0111] UE User Equipment

[0112] UL Uplink

1. A method for managing control channel usage in Carrier Aggregation, comprising:

defining a time reuse factor and a time reuse pattern for a Physical Uplink Control Channel resource on a Primary Cell for enabling time multiplexing the subframes of the resource; and

assigning a Physical Uplink Control Channel resource element to a requesting User Equipment by using colliding resources in different subframes,

wherein the time reuse factor and the time reuse pattern are variably set based on at least one of the number of requesting User Equipments and the individual traffic needs of the requesting User Equipment.

2. The method according to claim **1**, wherein a higher time reuse factor is an integer multiple of a lower time reuse factor.

3. The method according to claim **1**, wherein each Physical Uplink Control Channel resource element is uniquely associated with a Physical Uplink Control Channel resource, a predefined time reuse pattern and a time reuse factor.

4. The method according to claim **3**, wherein the time reuse patterns are preset so as to enable time hopping, wherein the period of time hopping is time reuse factor dependent or independent of the time reuse factor.

5. The method according to claim **4**, wherein a longer time hopping period is an integer multiple of a shorter time hopping period, and the time reuse patterns of different time reuse factors are time synchronized.

6. The method according to claim **1**, wherein the Physical Uplink Control Channel resources are organized in a tree structure, wherein

the corresponding levels of the tree are created by lowering the time reuse factor;

each element in the tree is uniquely associated with a Physical Uplink Control Channel resource, a predefined time reuse pattern and a time reuse factor, and at least one of Physical Uplink Control Channel resource and time reuse pattern is different across all elements on a given level;

each requesting User Equipment is allocated to one element of the tree for a defined periodic and/or event based time duration; and

different requesting User Equipments have elements allocated on the same and/or on different levels of the tree.

7. The method according to claim **6**, wherein collisions across elements on different levels of the tree are avoided